Edited by Bill Travis and Anne Watson Swager

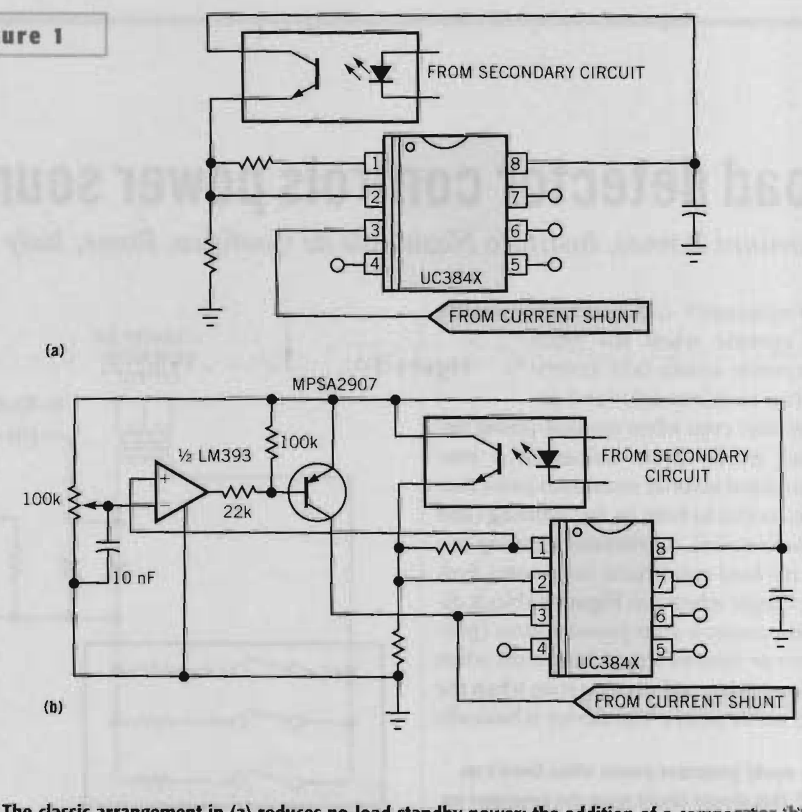
Controller IC halves switcher's standby power

Christophe Basso, On Semiconductor, Toulouse, France

THE QUEST FOR LOW standby power is a challenge for switch-mode-power-supply (SMPS) designers. You can split the definition of "standby" into two facets. In "no-load" standby, such as in a fully charged battery, output-power demand is nonexistent. In "light-load" standby, such as in a TV set awaiting a remote-control command, internal circuitry has turned off most of the power-hungry blocks, but some μC activity still takes place. The design in **Figure 1** covers both standby facets with a simple solution. **Figure 1a** depicts the way you could achieve the regulation using a classic optoisolated supply that uses a member of the UC384X family. When the output load decreases, the LED bias raises Pin 2 (the FB pin) and demands a lower peak current. At no load or light load, the PWM IC tries to reduce the duty cycle as much as possible. Unfortunately, high-frequency limitations lead to compromised performance at the lowest duty cycles, and the circuit can waste as much as 1.5W with a 30W SMPS operating at no load.

One possible solution uses a hysteretic regulator but, as you can imagine, the high peak currents switched in the audible range make the design of a quiet, medium-power SMPS a difficult task. An elegant solution would combine the best of both worlds: normal high-frequency operation in current mode and burst-mode operation when the output-power demand diminishes. **Figure 1b** shows how to apply the method to your UC384X-based design by simply adding a low-cost comparator. In nominal-power operation, the voltage on Pin 1 is higher than the level imposed by the 100-kΩ potentiometer's wiper, and the UC384X operates in its normal mode. When the load disappears, the voltage on Pin 1 drops to reduce the primary peak-current setpoint. If you adjust the potentiometer for a given peak level, the only way to further reduce the power is to stop the output pulses. The comparator, deriving its power from the UC384X's internal reference, biases the pnp transistor and brings the current-sense pin to the

Figure 1

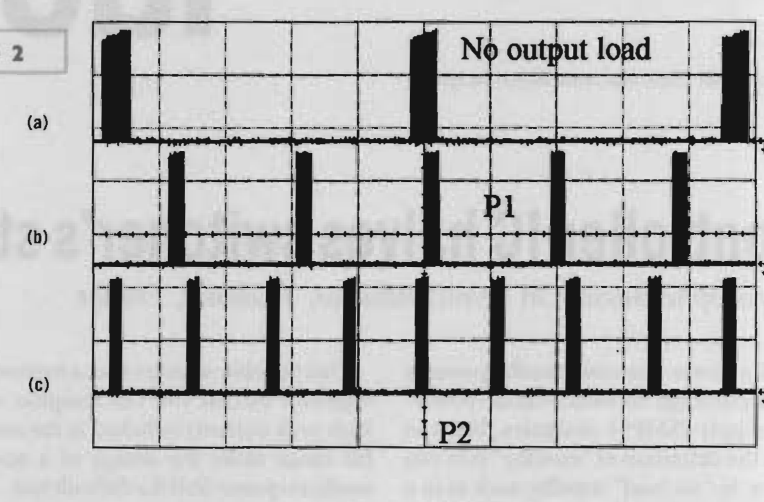


The classic arrangement in (a) reduces no-load standby power; the addition of a comparator (b) cuts the standby power by 50%.

level at Pin 8. This action blocks the output pulses, and the circuit delivers no power.

The output voltage decreases, and, as soon as the error amplifier's level crosses the level at the potentiometer's wiper, the pulses reappear for another time packet. In other words, the circuit goes into burst mode. Thanks to the lack of hysteresis in the comparator, the output ripple is minimal. However, you must prevent the UC384X from entering hiccup mode during the burst-mode operation to preserve good transient response. Increasing the power-rail bulk capacitor can prevent hiccup mode. If the circuit enters hiccup mode, the power consumption further decreases but to the detriment of the transient response. **Figure 2** shows how the circuit behaves at different load conditions. By adjusting the level at the comparator's inverting input, you have the flexibility to make the supply enter burst mode at a peak value at which no acoustic noise results. You can also select the output level at which the circuit enters burst mode: a no- or light-load condition. With a typical 12V, 30W flyback supply using a UC3843, measurements reveal an input power of 1.35W at no load (V_{IN}=100V ac; $R_{STARTUP}$=100 kΩ). Adding the comparator reduces the input power to 770 mW. (DI #2436)

Figure 2



Burst-mode pulses reflect a no-load condition (a) and different light-load conditions (b and c).

TO VOTE FOR THIS DESIGN,
CIRCLE NO. 494

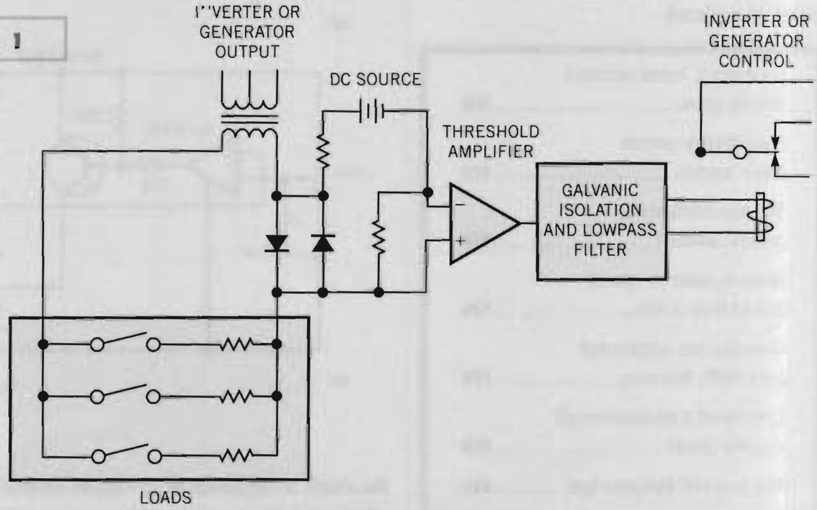
Load detector controls power sources

Giovanni Romeo, Instituto Nazionale de Geofisica, Rome, Italy

EMERGENCY GENERATORS normally operate when the main power source fails. Inverters run continuously (and expensively) even when no load-power demand exists. Even unloaded, a medium-sized inverter consumes some tens of watts just to keep its fan running (and to make noise). A generator running under no-load conditions just wastes fuel. The simple scheme in **Figure 1**'s block diagram controls your power source (generator or inverter), switching it off when no load exists and turning it on when the load needs power. The device is basically

Why waste generator power when there's no load? This simple circuit turns the generator on only when a load demands power.

Figure 1



an ohmmeter that monitors the generator resistance of the generator or inverter output. Usually, the output comes from a motor coil or a transformer winding having low resistance. The circuit in **Figure 1** can detect any load whose resistance is lower than 15 kΩ. When no load exists, the voltage at the amplifier input (the generator's voltage minus the diode-junction voltage) does not exceed the threshold, so the relay does not engage.

When one or more loads connect to the circuit, the voltage at the amplifier input exceeds the threshold, actuating the relay and starting the generator or inverter. When the ac load current flows through the circuit, it keeps the relay engaged. When the load disconnects, the relay disengages. In operating a generator, you should wire the system to start the generator when no line power exists *and* when the load requires power. **Figure 2** shows a complete schematic. In the no-load case, the voltage source (R_1, R_2, D_1, and D_2) cannot forward-bias Q_1's base-emitter junction, because of the voltage drop across D_3, D_4, and D_5. The junction becomes forward-biased when a load connects to the inverter, and the load current flows through the output coil (inverter or generator transformer). The high-voltage section of the circuit is galvanically isolated via the dc/dc converter and the optocoupler. An RC lowpass filter delays the relay's actuation; it takes approximately 1 sec for the relay to engage after connecting the load and 2 sec to disengage after disconnecting the load. (DI #2435)

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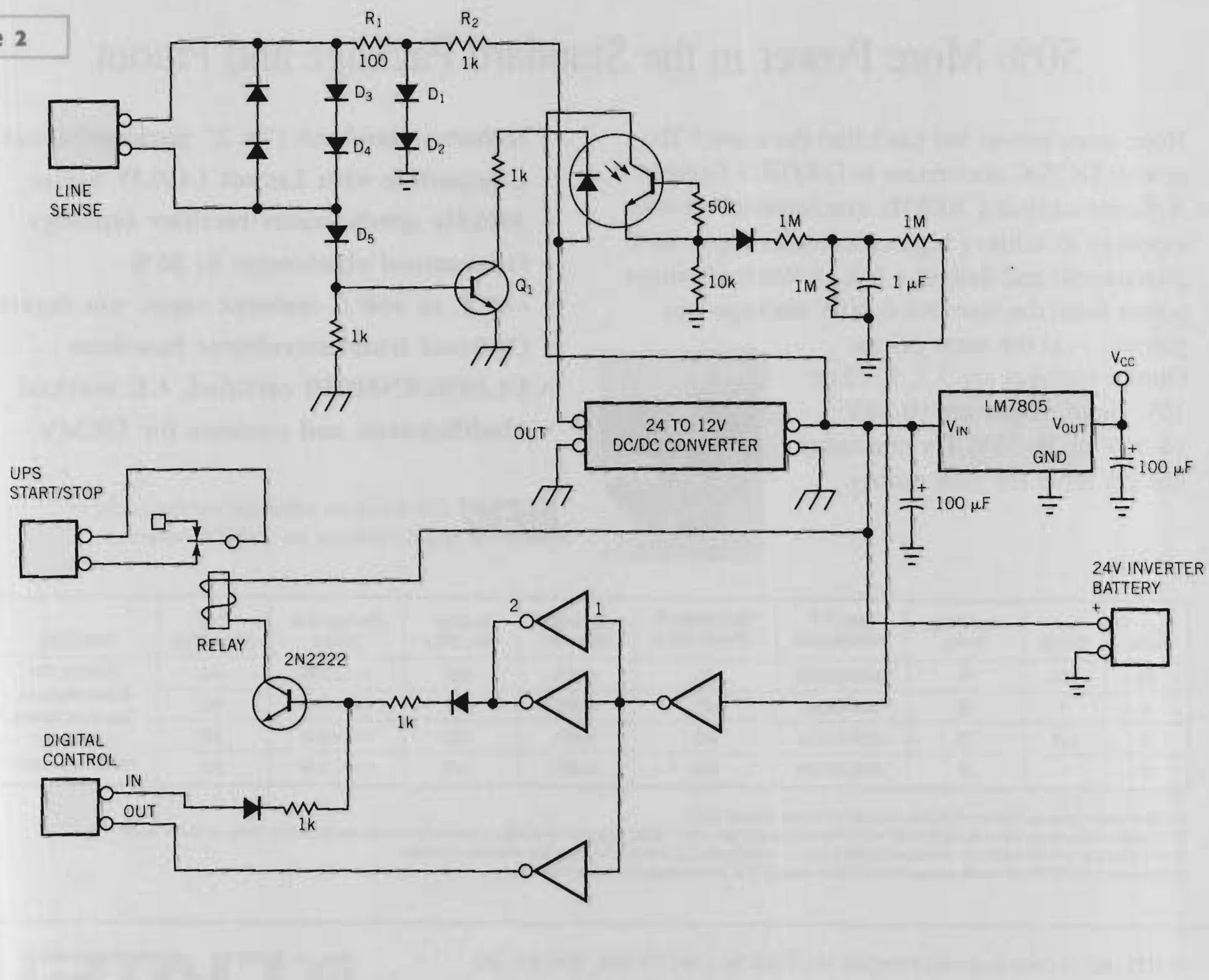
Figure 2



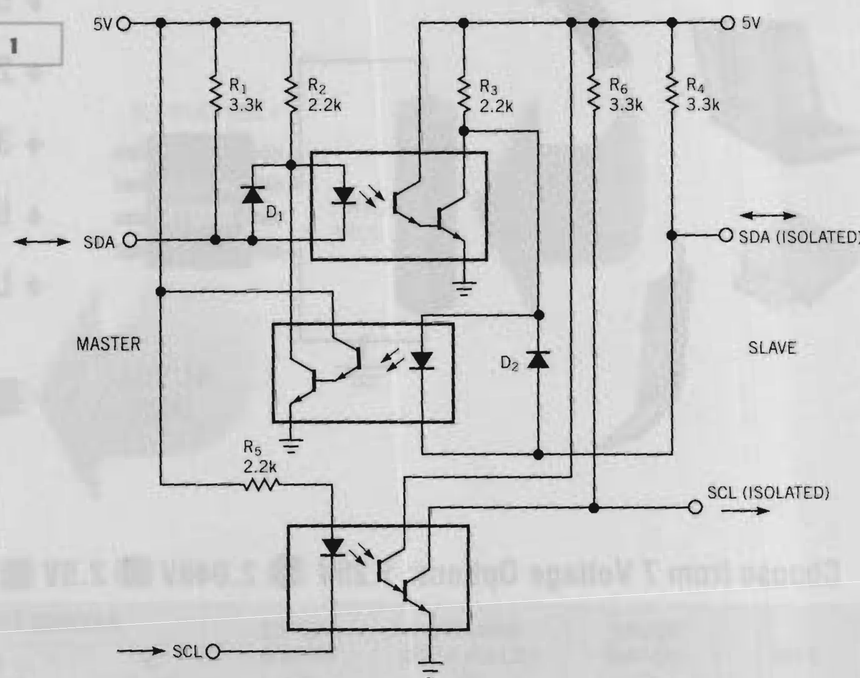
This galvanically isolated generator-control circuit turns on the emergency generator only when the load demands it.

Two-wire interface has galvanic isolation

Minh-Tam Nguyen and Martin Baumbach, Maxim Integrated Products, Munich, Germany

Unlike the four-wire SPI, QSPI, and Microwire data-interface standards, I^2C and SBBus buses require only two wires for data transmission, because they send and receive over the same wire. The circuit in **Figure 1** provides galvanic isolation for the two-wire interface. A small transformer and a MAX253 transformer driver (not shown) derive an isolated 5V rail from the master-side 5V rail. The data rate and isolation-barrier voltage in your application guide the selection of the transformer and optocoupler. The circuit in **Figure 1** uses a Hewlett-Packard 6N138 optocoupler. For more information on component suppliers, see the MAX253 and MAX845 data sheets. The scheme assumes a µP or µC for the master device, and the current-sink limitation of the processor's SDA terminal dictates that the optocoupler's minimum on-state current be less than 3 mA. Even so, the optocoupler's 300% current-transfer ratio (CTR) is adequate to ensure proper operation in this circuit.

Figure 1



A handful of components provides an isolation barrier for the two wires of an I^2C transmission interface.

The slave side should host an I^2C-compatible device, such as the MAX517 8-bit DAC or the MAX127 data-acquisition system. The master-side SDA and SCL signals are high when the bus is not in use. The I^2C Start condition is typically a high-to-low transition on SDA while SCL remains low (**Figure 2**). With SDA low, current through R_2 and the optocoupler's input causes the opto output to produce a signal of approximately 0.4V (sum of the opto output and the forward-biased Schottky diode, D_2). Pull-up resistors R_1, R_4, and R_6 are necessary for I^2C compatibility. After the master addresses the slave as described, the addressed slave responds with a low-level acknowledge bit. The bidirectional SDA line allows data transfer in both directions, but the unidirectional SCL line needs only to conduct signals from master to slave. Data transmission ends with the Stop condition, in which SDA typically makes a low-to-high transition while SCL is high. (DI #2438)

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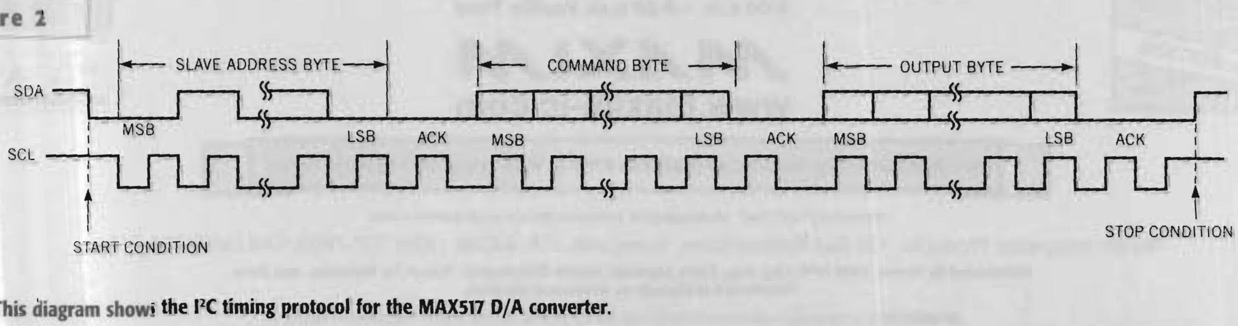
Figure 2



This diagram shows the I^2C timing protocol for the MAX517 D/A converter.

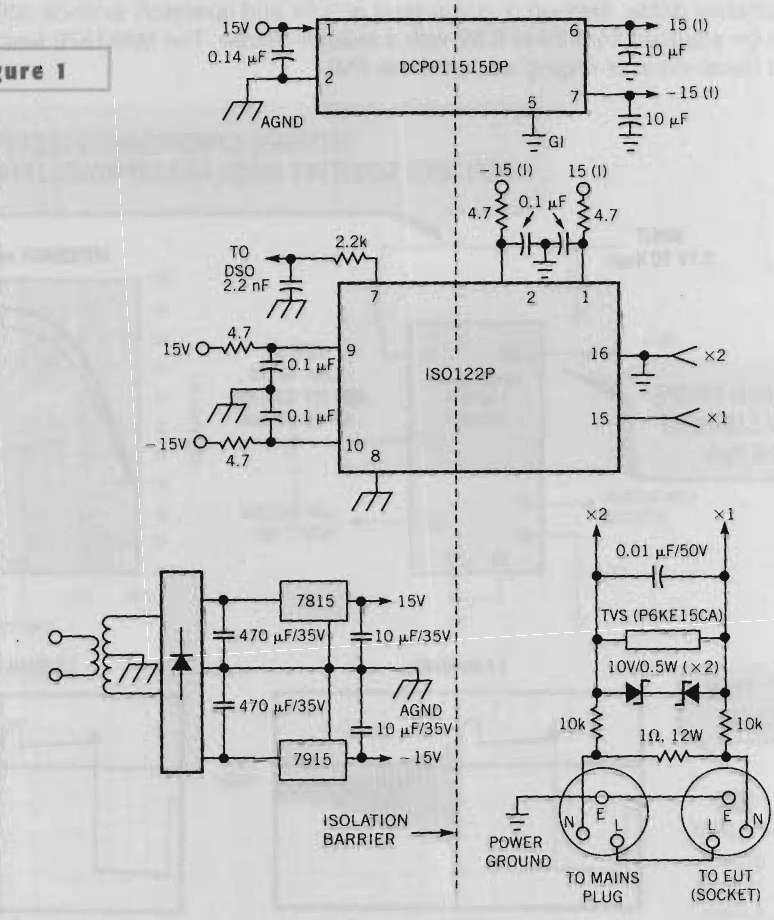
Measure power-on current transients on ac line

N Kannan, Mediatronix, Trivandrum, India

For any electronic or electrical system, you usually determine the ac-line fuse rating based on the steady-state current. However, the power-on current surge is an important parameter in determining the fuse's I^2t rating. The I^2t rating is a measure of the energy required to blow a fuse in pulsed conditions. Also, in many cases, you may find it of value to know the shape of the current surge and its harmonic content. The circuit in **Figure 1** can help you capture the power-on current transients in a system. The circuit costs less than $25 to build. You need a DSO to capture the waveforms. In **Figure 1**, the neutral line of the equipment under test contains a 1Ω, 12W current-sense resistor. The resistor should be able to handle10A surge current and 3A steady-state current. The voltage drop across the sense resistor drives an ISO122P isolation amplifier (Burr-Brown, www.burr-brown.com). The zener diode and the transient-voltage suppressor provide overvoltage protection.

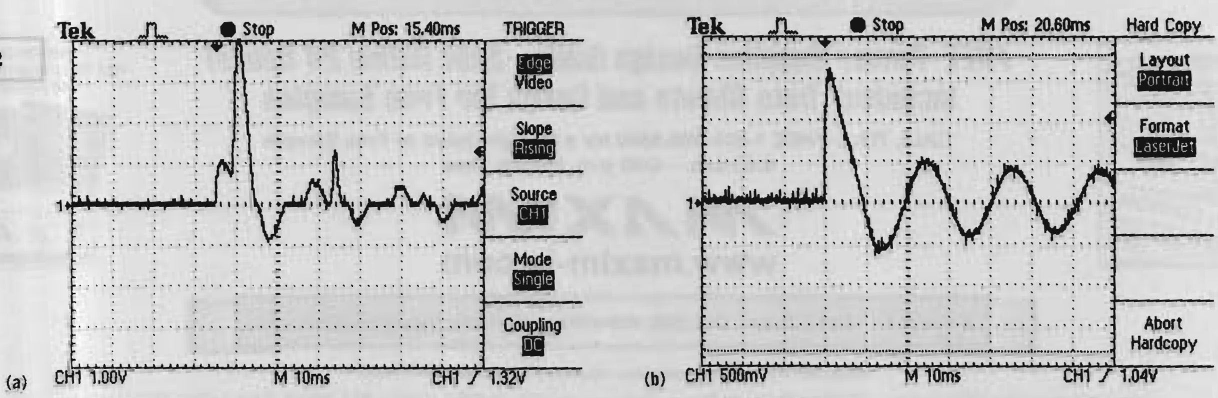
A DCP011515DP isolated dc/dc converter (also Burr-Brown) generates ±15V isolated supplies to power the input side of the ISO122P. Both devices provide more than a 1000V rms isolation capability. A local supply powers the in-

Figure 1



This simple tester allows you to measure power-on current surges.

Figure 2



A highly capacitive power supply causes a 4A current surge (a) in the power line; an incandescent bulb produces a 1.5A spike (b).

put of the dc/dc converter and the output side of the ISO122P. The filtered output of the ISO122P provides the input to a DSO. You use transient-capture mode in the DSO to capture the power-on current surge. **Figure 2** shows the waveforms for:

- A system with a 10,000-μF transformer/bridge-capacitor filter (**Figure 2a**). Steady-state rms current is approximately 0.13A at 220V rms.
- An incandescent lamp (**Figure 2b**). From the waveforms, you can determine the surge's shape, width, and peak value. You can then use this information to determine the proper I^2t rating for the system fuse. **Figure 2a** shows a current surge of 4A peak, although the steady-state current is only 0.13A. The heavy surge arises because of the large-value capacitor filter and also from core-saturation effects. **Figure 2b** shows a turn-on surge of approximately 1.5A for the 60W, 220V incandescent bulb. Warning: Hazardous voltages are present in the mains-side circuitry. (DI #2428).

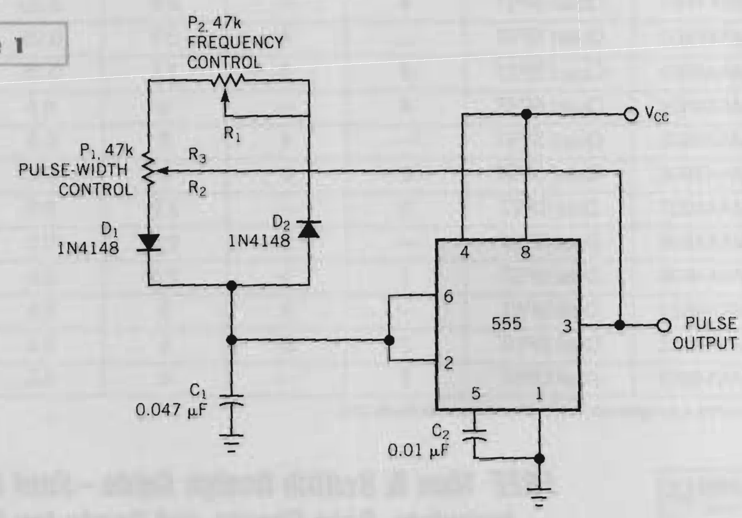
TO VOTE FOR THIS DESIGN,
CIRCLE NO. 497

Generator has independent pulse width, frequency

Darvinder Oberoi, CEDTI, Jammy, India

A COMMON CIRCUIT in electronics is the square-wave, astable multivibrator (one-shot), which is useful for various purposes, such as timing circuits and audible alarms. The most common way to generate the desired square wave is to use the inexpensive 555 timer. The need sometimes arises for a square wave with fixed frequency but variable pulse width or vice versa. It's difficult to satisfy these requirements with a conventional 555-based astable circuit. **Figure 1** shows a modification of the basic 555-based astable circuit. You can use the circuit to generate stable, variable-pulse-width or variable-frequency signals, which are independent of each other by means of individual dedicated controls. The Pin 3 output of the 555 charges and discharges C_1. D_1 and D_2 provide individual paths for the charging and discharging operations, respectively. The two timing potentiometers, P_1 and P_2, control the RC_1 time constant during the charging and discharging cycles.

Figure 1



You can independently and noninteractively control pulse width and frequency by adjusting two potentiometers.

When Pin 3 of the 555 is high, the capacitor charges through R_2 (a component of P_1, whose value depends on the wiper position). When C_1 charges to two-thirds V_{CC}, Pin 3 goes low, and C_1 discharges through the combination of D_2, P_2 (resistance R_1), and P_1 (resistance R_3). When the voltage across C_1 reaches one-third V_{CC}, the Pin 3 output again switches high. The process of alternately charging and discharging C_1 continues; the result is an output with a desired pulse width and frequency. Because the forward resistance of the diodes is negligible, the pulse width equates to $R_2C_1\log(2)$. The pulse period (reciprocal of frequency) is $0.693(R_1+R_2+R_3)C_1$. Thus, the pulse width is independent of P_2's wiper position, and the frequency is independent of P_1's wiper position. (DI #2444)

TO VOTE FOR THIS DESIGN,
CIRCLE NO. 498

Customized potentiometers aid amplifier design

Chuck Wojslaw, Xicor Inc, Milpitas, CA

The circuit in **Figure 1** is a model of an amplifier circuit whose cutoff frequency and gain are functions of the values of variable resistors. A first-order, RC lowpass filter establishes the cutoff frequency, and a traditional noninverting op-amp circuit determines the gain. You can add variability and programmability if you use digitally controlled potentiometers to implement the variable resistors. The circuit in **Figure 2** shows the implementation of the frequency and gain controls. The potentiometer, R, forms a pseudo-tee network; along with capacitor C, the potentiometer establishes the upper cutoff frequency f_C. Potentiometer R_2 is a three-terminal device that establishes the voltage gain, G_0. The voltage gain for the circuit is:

$$\frac{V_0}{V_S}=\frac{G_0\omega_C}{j\omega+\omega_C}.$$

G_0 is the programmable closed-loop passband gain:

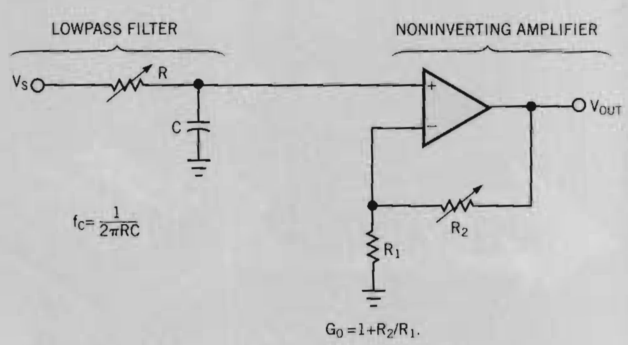
$$G_0=\frac{R_1+R_2}{R_1+k_2R_2},\text{ and } 0\le k_2\le 1,$$

where k_2 reflects the proportionate position of the wiper from one end of the potentiometer (0) to the other end (1). The gain is programmable from 1 to $(R_1+R_2)/R_1$. The fixed resistor, R_1, limits the circuit's maximum voltage gain, a limitation usually necessary for accuracy and bandwidth purposes. The upper cutoff frequency f_C is a function of the input RC network:

$$f_C=\frac{\omega_C}{2\pi}=\frac{1}{2\pi(k_1R)C},\text{ and } 0\le k_1\le 1.$$

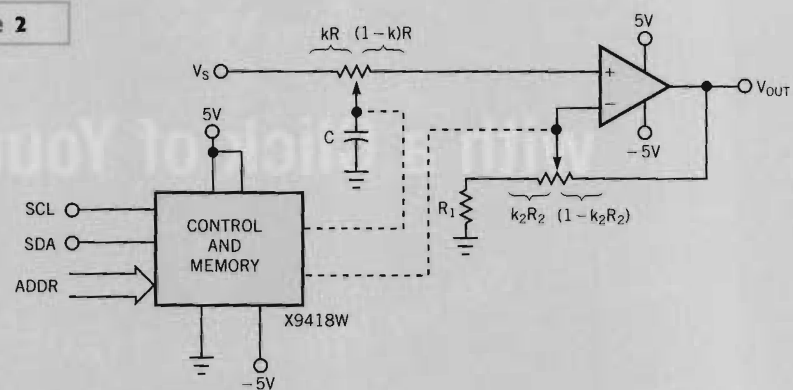
where k_1, like k_2, reflects the proportionate position of the wiper from one end of the potentiometer (0) to the other end (1). The dual versions of the XDCP digital potentiometers use the same serial bus with different addresses for the individual potentiometers.

Figure 1



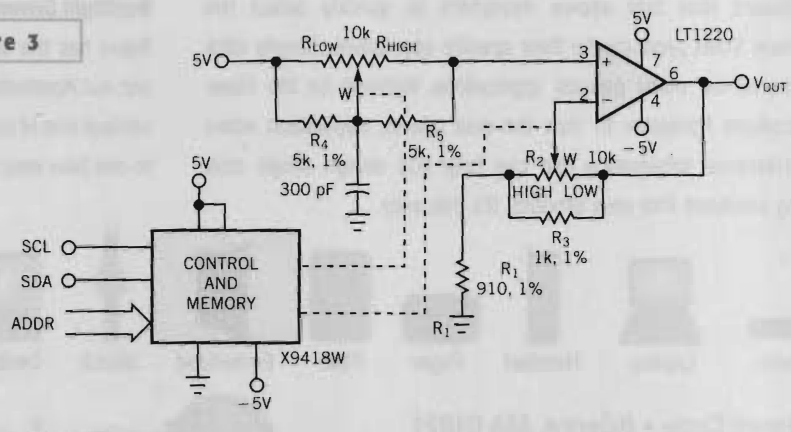
You can use potentiometers to program an amplifier's gain and cutoff frequency.

Figure 2



Replacing Figure 1's potentiometer with digitally programmable potentiometers allows you digitally to control gain and cutoff frequency.

Figure 3



You can use the same serial bus to control both the gain and the cutoff-frequency potentiometers in an amplifier circuit.

For high-frequency amplifiers, the 10-kΩ end-to-end resistance of the X9418 creates time constants limiting the bandwidth of the circuit. You can reduce the effective end-to-end resistance of the potentiometers by using two techniques shown in the high-frequency amplifier circuit in **Figure 3**. If you connect the wiper of the potentiometer to a high impedance, shunting R_{TOTAL} directly with an external resistor reduces the effective end-to-end resistance. Resistor R_3 changes the effective end-to-end resistance of potentiometer R_2 from 10 to 0.909 kΩ. If you do not connect the wiper of the potentiometer to a high impedance, you can reduce the effective end-to-end resistance by adding external, equal-value resistors, R_4 and R_5, from the wiper to the high and low terminals. This technique, however, creates a potentiometer whose taper is pseudolinear and whose end-to-end resistance varies with wiper position by approximately 20%. The gain of the amplifier circuit in **Figure 3** is programmable from 1 to 2, and the cutoff frequency is programmable from 130 kHz to more than 1 MHz. (DI #2437)

To Vote For This Design,
Circle No. 499

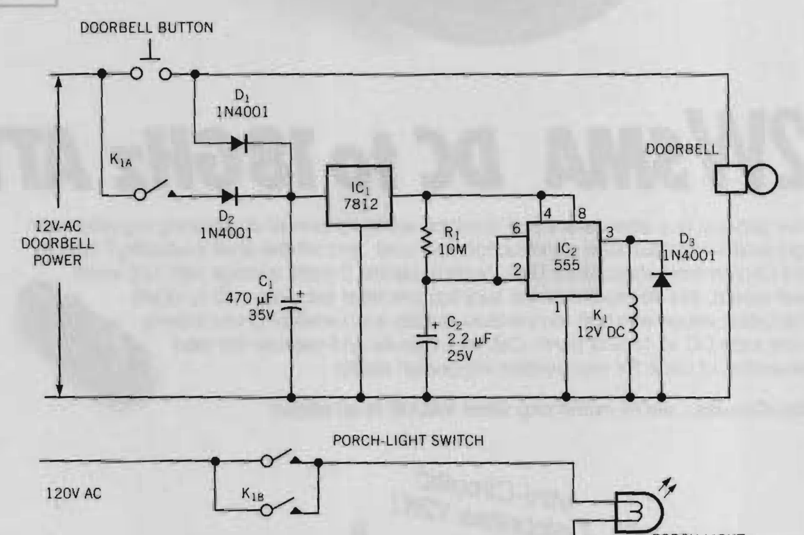
Ring your bell; light your light

Dennis Eichenberg, Parma Heights, OH

The circuit in **Figure 1** provides a simple and inexpensive way to provide illumination for a dark doorway. Pressing the doorbell button momentarily rings the doorbell and turns on the porch light. The porch light remains on for approximately 25 sec and then turns off. This interval is long enough for a person to find his or her way when it's dark. The system also provides security in that anyone pressing the doorbell button is automatically illuminated. The circuit receives its power from the doorbell system. Pressing the doorbell button provides voltage to diode D_1, which acts as a half-wave rectifier. D_1 also acts as a blocking diode to prevent current from flowing back to the doorbell after you release the doorbell button. Capacitor C_1 filters the half-wave-rectified voltage, and voltage regulator IC_1 regulates the filtered voltage. The regulated voltage supplies timer IC_2, configured as a monostable multivibrator.

Relay K_1 activates when you press the doorbell button. It remains activated until IC_2 times out, according to the expression $t=1\cdot 1R_1C_2$. Diode D_3 is a flyback diode to protect IC_2 from the inductive spike K_1 generates when it becomes deactivated. Normally open relay contact K_{1A} continues to power the circuit via diode D_2 after you release the doorbell button. K_{1B} connects in parallel with the porch-light switch to power the porch light by means of the new circuit. You must size the relay contacts to accommodate the current requirements of the porch light. (DI #2433)

Figure 1



Scared of the dark? Use this circuit to turn on your porch light when you ring the doorbell.

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